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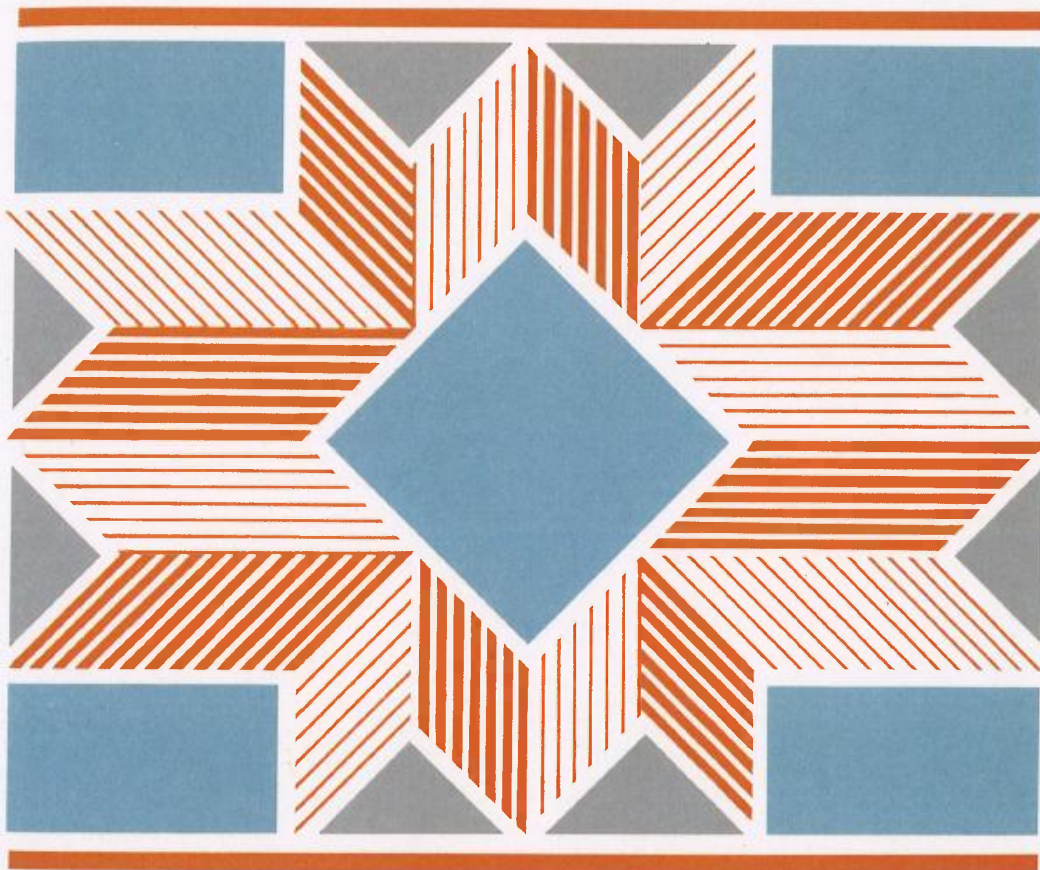
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Essentials of Data Processing

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Essentials of Data Processing

*The Times Mirror/Mosby Data Processing and Information
Systems Series*

Cohen/Alger/Boyd **Business BASIC for the IBM PC with Cases**

Dravillas/Stilwell/Williams **Power Pack for the IBM PC**

Floyd **Essentials of Data Processing**

Spence/Windsor **Using Microcomputers: Applications for Business**

Spence/Windsor **Microcomputers in Business: WordStar, dBase II
and III, and Lotus 1-2-3**

Lientz/Rea **Data Communications for Business**

Whitten/Bentley/Ho **Systems Analysis and Design Methods**



Essentials of Data Processing

NANCY A. FLOYD



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Brief Contents

Detailed Contents	vii
Preface	xvii
Chapter 1	<i>Introduction</i> 1
Chapter 2	<i>Hardware: The Peripheral Devices</i> 18
Chapter 3	<i>The Central Processing Unit and the Operating System</i> 44
Chapter 4	<i>Software</i> 60
Chapter 5	<i>The Programming Process</i> 81
Chapter 6	<i>Microcomputers</i> 104
Chapter 7	<i>File Organization</i> 124
Chapter 8	<i>Database</i> 137
Chapter 9	<i>Microcomputer Applications</i> 150
Chapter 10	<i>Telecommunications</i> 170
Chapter 11	<i>Office Automation</i> 186
Chapter 12	<i>Trends</i> 203
Appendix A	<i>BASIC</i> 215
Appendix B	<i>Data Representation</i> 229
Glossary	240
Index	250



Detailed Contents

Each Chapter begins with "At XFields, Inc."—a short business scenario—and an Overview. Each Chapter concludes with a summary, "At XFields: Conclusion," and Exercises and Projects.

CHAPTER 1

Introduction

1

<i>What Is a Computer?</i>	3
<i>From Calculating Machines to Computers</i>	4
The First "Computer"	5
Punched Cards and the 1890 Census	6
The Electromechanical Computer Arrives	7
The Electronic Computer: Who Gets the Credit?	7
Separation of Computer and Program	8
<i>Building on the Foundation</i>	9
The First Generation: Computers Reach Private Industry	10
Transistors: The Second Generation Begins	11
The Third Generation: Computers and Their Families	12
The Fourth Generation: A Population Explosion	14
Learning from Experience: The Fifth Generation	15
Where Are Computers Today?	15

CHAPTER 2

Hardware: The Peripheral Devices

18

<i>Input Devices and Media</i>	20
Terminals	20

vii

CHAPTER 5

The Programming Process

81

<i>What Is Programming?</i>	83
<i>What Is Systems Analysis?</i>	83
The Systems Analysis Process	84
<i>Programming Logic</i>	85
<i>Flowcharts</i>	86
Flowcharting Symbols	86
Logic Flow	89
Loops	89
Branches	90
<i>Structured Programming</i>	92
Structure Charts	92
IPO Charts	93
Pseudocode	93
Structured Code	93
<i>Coding the Program</i>	94
<i>Testing the Program</i>	96
Syntax Errors	96
Logic Errors	97
<i>Marking the Trail</i>	99
Documentation for Maintenance	99
Documentation for Operators	100
Documentation for Users	101
Training Operators and End Users	101

CHAPTER 6

Microcomputers

104

<i>Brief History of Microcomputers</i>	105
<i>Microcomputer Characteristics</i>	106
Hardware	107
Software	107
Operating Systems	107
Applications Software	108
<i>The Users</i>	110
Individuals	110
Educators	110

Small Businesses	111
Large Businesses	112
<i>Criteria for Selecting and Evaluating a System</i>	116
Criteria for Evaluating Software	116
Criteria for Evaluating Hardware	118
<i>Caring for Your System</i>	119
<i>Trends in Microcomputers</i>	120
Trends in Development	120
Trends in Use	120
Trends in Sales	121

CHAPTER 7***File Organization*****124**

<i>Data Structure</i>	125
<i>Space Considerations</i>	126
Record Types: Fixed versus Variable	126
Blocking	127
Packing	128
<i>File Organization</i>	129
Sequential File Organization	129
Direct File Organization	130
Relative File Organization	130
Indexed File Organization	130
<i>Processing Methods</i>	131
Batch Processing	132
Transaction-oriented Processing	132
<i>Access Methods</i>	132
Accessing Sequential Files	133
Accessing Direct and Relative Files	133
Accessing Indexed Files	133
Access Method Programs	134

CHAPTER 8***Database*****137**

<i>Why Did Database Evolve?</i>	139
<i>What Is a Database?</i>	139
<i>Advantages of Database Organization</i>	139

Data Redundancy	141
Data Integrity	141
Data Security	141
Shared Data	141
<i>Data Management System</i>	147
Purpose	142
Data Dictionary	143
Query Language	143
<i>Shared Files</i>	144
<i>Types of Database</i>	144
Hierarchical Database	144
Network Database	144
Relational Database	147
Problems	147

CHAPTER 9 **Microcomputer Applications** **150**

<i>Symphony</i>	152
<i>Spreadsheets</i>	152
Layout	152
Spreadsheet Windows	152
How the Spreadsheet Is Used	153
<i>Graphics</i>	156
<i>Word Processing</i>	157
<i>Database</i>	163
<i>Other Applications</i>	165
<i>Trends</i>	165

CHAPTER 10 **Telecommunications** **170**

<i>Hardware</i>	172
Terminal	172
Modem	174
Communications Channel	174
Telephone Lines	174
Coaxial Cable	175
Fiber Optics	175

Microwave	176
Satellites	176
Computer and Front-end Processor	177
Networks	178
Point-to-Point Network	179
Star Network	180
Ring Network	180
Line Control	181
Distributed Data Processing	181
Current Issues	181
Privacy	181
Security	182
Ethics	182
Trends	183

CHAPTER 11

Office Automation

186

The Office Yesterday and Today	187
What the Office Really Is	188
How the Office Is Changing	189
Some Changing Technologies	189
Word Processing	198
Electronic Mail	190
Facsimile Systems	191
Teleconferencing and Telecommuting	191
Integrated Voice and Data	196
Effect on People	197
Trends	200

CHAPTER 12

Trends

203

Decision Support Systems	205
Components	205
Users	206
The Future	206
Robotics	206

<i>The Intelligent Machine</i>	208
Artificial Intelligence	210
AI and Japan's 10-year Plan	211
Expert Systems	211
Natural Languages	212

APPENDIX A

BASIC

215

<i>Error Correction</i>	216
<i>System Commands</i>	216
NEW	217
LIST and LLIST	217
RUN	217
SAVE	217
LOAD	217
<i>Data Representation</i>	217
Numeric Variables	218
String Variables	218
<i>Reserved Words</i>	218
<i>Line Numbers</i>	218
<i>Spaces</i>	218
<i>Line Format</i>	219
<i>INPUT/OUTPUT and Miscellaneous Statements</i>	219
REM Statement	219
INPUT Statement	219
PRINT and LPRINT Statement	220
READ Statement	221
DATA Statement	221
LET Statement	222
END Statement	223
<i>Branching</i>	223
GOTO Statement	224
IF/THEN/ELSE Statement	224
FOR NEXT Statement	225
<i>Subroutines and the GOSUB Statement</i>	226

APPENDIX B**Data Representation****229***Numbering Systems* 229

Decimal and Binary Numbers 229

Octal Numbers 230

Hexadecimal Numbers 234

Coding Schemes 235

EBCDIC 236

ASCII 238

Glossary 240*Index* 250



Preface

The Intended Audience for This Book

The growth and development of the data processing field have affected almost every aspect of our lives. Consequently, the student taking an introductory data processing course today may be majoring in computer studies, may be in a related field such as business, or may use computers only in support of his or her area of expertise. This diverse group of students—enrolled in 2- and 4-year colleges, nonmajors and majors—has one important unifying goal: the need to learn fundamental computer concepts. By providing in-depth coverage of *essential* data processing concepts, *Essentials of Data Processing* is intended to support a practical first course in data processing for nonmajors and for majors enrolled in a combined introductory data processing/BASIC or introductory data processing/microcomputer applications course.

Why This Book Was Written

Students today are interested in what practical information they need to deal with the computer in the workplace. They need to learn key concepts and important terminologies without being burdened with unnecessary detail. This book was written because the available textbooks did not satisfy students' needs. Specifically:

The big, 4-color introductory data processing books are *too* big for some courses.

xvii

- *They contain too much material to cover in the time available.* Some professors attempt to make the big books "fit" their courses by omitting chapters and thereby also eliminating coverage of valuable concepts. Some professors try to solve this problem by using only selected readings from within each chapter, thereby creating gaps that cause problems in student comprehension. And even more elaborate "text surgery" is necessary if the professor wants also to cover BASIC.
- *Material may be deleted, but the price remains the same.* Professors pay the price in time spent tailoring the book to meet their course needs, and students pay the price for an expensive, 4-color book of which they use only a portion.

The smaller introductory data processing books miss the mark in satisfying course needs.

- *Some texts have shallow coverage of too few concepts.* These texts, in attempting to be "shorter" than the bigger books, end up containing material that is not technical enough. The coverage lacks depth and fails to include important topics.
- *Many texts do not have a practical orientation.* Some texts contain material that is too technical for nonmajors, for example, focusing primarily on programming. Some texts focus on the societal implications of the computer. Some texts don't devote enough coverage to microcomputers. These texts don't address what the average person needs to know about dealing with computers in career and family activities.

Why You Should Consider This Book

I really believe *Essentials of Data Processing* will better suit your course needs than any other book because:

- *This book is designed so that all the material can be covered in one term, with or without a lab.* This permits maximum flexibility for those instructors who want to cover BASIC programming or microcomputer applications, as well as essential data processing concepts. The decision to include topics was based on whether that information was essential to both majors and nonmajors and whether the material was usually covered in another course. For example, Chapter 5, The Programming Process, includes *brief* coverage of systems analysis—only those concepts pertinent to the average nonmajor. Majors will go on to take a one-term and sometimes a two-term Systems Analysis and Design Course.
- *This book offers a practical, microcomputer-oriented approach to data processing concepts.* Content is presented so that students can identify with it and immediately transfer it into their own lives. Students are taught what they need to know to interact with computers and the per-

sons who program computers. Also, the book covers *practical* information about the type of computer students are most likely to encounter—the microcomputer. The microcomputer orientation throughout the text is additionally bolstered by two chapters that are microcomputer specific. Chapter 4, Software, includes guidelines for evaluating and purchasing software and for storing and handling diskettes. Chapter 6, Microcomputers, includes a checklist for purchasing hardware.

- *This book is up-to-date.* Topics covered include office automation, robotics, decision support systems, fifth-generation computers, expert systems, and artificial intelligence.
- *Carefully developed in-text learning aids ensure student comprehension:*
 - *At XFields, Inc.* All chapters begin with a short business-oriented scenario that sets the scene for the topics to be covered in the chapter. Students will identify with the characters' real-life job concerns and anxieties about using computers and be motivated to study the chapter.
 - *Chapter Objectives.* After studying the chapter, students can use the list of objectives to test their understanding of the chapter contents.
 - *Overview.* Following the Chapter Objectives is a brief introduction that previews chapter content.
 - *On the Job Boxes.* Each chapter contains this feature, which highlights how computers are used in the business world and reinforces chapter concepts.
 - *Summary.* All chapters end with a brief section summarizing the topics covered. Students can use this feature for review and study purposes.
 - *At XFields: Conclusion.* Each chapter ends by returning to the XFields characters introduced at the beginning of the chapter. Because the characters' learning parallels what students have learned in the chapter, students will again identify with the characters.
 - *Definitions.* Terms are boldfaced and defined on first mention within chapters. All boldfaced terms appear in the end-of-text glossary.
 - *Exercises.* Each chapter ends with discussion questions that test student comprehension of chapter content.
 - *Projects.* Following the *Exercises* are *Projects* to expand students' learning experience beyond the text.
- *This book was written for students.* The book presents essential concepts in a concise, clear, easy-to-understand manner so that students are interested and encouraged, not intimidated by computers. Discussions are not overly technical. Concepts are explained through the use of objects and events with which students can relate. For example, in the explanation of how matrix construction creates letters, the matrix pins of a printer are compared to the individual bulbs that light up to show the score on a basketball scoreboard (Chapter 2). The functional use of a second color also enhances student interest.

How to Use This Book

Essentials of Data Processing is designed so that all material may be completed in one term. Specific suggestions on how to use the book in the various course configurations can be found in the Instructor's Guide.

Professors have the flexibility to decide to:

Use the book by itself.

This book is self-contained; it covers all essential computer concepts. If the class is taught without a lab, the Projects at the end of each chapter will offer students some exposure to computer usage. If the course is taught with a programming lab, the BASIC appendix can be used.

Use this book with a language supplement.

This book is available with an accompanying BASIC supplement (Student Study Guide) that builds on the in-text BASIC appendix. Times Mirror/Mosby's Cohen-Alger-Boyd *Business BASIC for the IBM PC with Cases* (for a machine-specific, business approach) might be suitable, or another language supplement can be used.

Use this book with a microcomputer supplement.

This text may be used with Times Mirror's texts Dravillas-Stilwell-Williams *Power Pack for the IBM PC*, which offers generic explanation of packages and comes with software; Spence-Windsor *Using Microcomputers: Applications for Business*, which offers generic concepts and hands-on coverage of 15 popular business packages and comes with software; or Spence-Windsor *Microcomputers in Business: WordStar, dBASE II and III, and Lotus 1-2-3*. Or professors can use another microcomputer text or supplement of their choosing.

Use this book with a language and a microcomputer supplement.

Many instructors today want to teach an introductory course that covers data processing concepts, programming, and microcomputer applications. Again, this book can be used as the ideal compliment to other required texts.

Supplements

A solid package of instructional supplements has been created with the needs of the large number of adjunct faculty, part-time faculty, and teaching assistants foremost in mind.

Instructor's Guide

This supplement was written by Nancy A. Floyd and contains:
Answers to all exercises in the book and the Student Study Guide.
Chapter outlines to use as lecture guides.

100 transparency masters of key figures in the text, modifications of text figures, and totally new illustrations.

Conversion notes to help you convert from your present text.

Additional lab exercises and lecture materials to supplement text.

Accompaniment notes that address how to use this book (1) with a BASIC text, (2) with a microcomputer text, and (3) with a BASIC and a microcomputer text.

Teaching tips for the instructor.

Annotated journal references.

Topics for discussion relevant to chapter content.

Student Study Guide

This supplement was written by Paul W. Ross of Millersville University, Pennsylvania.

The first part of the Student Study Guide supports the chapters and contains:

Learning objectives

Overview Chapter summary

Problem set to define key terms

Discussion questions

Multiple choice, true/false, matching, and short-answer questions

Additional projects

Case studies with problem/activity sets

The second part supports and builds on the BASIC appendix, by covering:

- The mechanics of using BASIC on a microcomputer
- Numeric and string variables
- Reserved words and operators
- Simple input and output
- Assignment statements
- Looping and decision making
- Arrays, tables, and strings
- Subroutines
- File processing

Also included are:

Self-test questions

Programming problems

Test bank

The test questions were also written by Nancy A. Floyd.

The printed version of the test items includes approximately 1300 items using the following formats:

- Multiple choice
- Short answer
- Fill-in-the blank
- True/false
- Matching

A computerized testing package, Microtest, is available from the publisher to all adopters.

Acknowledgments

I am indebted to the many people who contributed to the development of this book: my family, who supported my decision to write and accepted the many other things that did not get done this year, and the reviewers, whose feedback and suggestions were invaluable.

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I assume full responsibility for any errors or inaccuracies. Any comments, criticisms, suggestions, or improvements are welcome. Write to me in care of Times Mirror/Mosby 4633 Old Ironsides Drive, Suite 410, Santa Clara, CA 95054.

Nancy Arthur Floyd

The Central Processing Unit and the Operating System

AT XFIELDS, INC.

■ Anne MacDermott watched Sam settle in at his desk. Five years ago they had both been computer operators; after that time and two upgrades in the system, she doubted that she would be much of an operator anymore.

She spent most of her time these days scheduling jobs and then explaining why schedules weren't met.

Last Wednesday had been one of those days that took a lot of explanation. The field service engineer had come in to make a minor repair and ended up crashing the entire system. Forty users suddenly stopped in the middle of whatever they were doing. Being able to run several programs at once might be great for getting jobs through when the system ran properly, Anne thought, but it sure kept the telephone lines busy when the system failed.

CHAPTER OBJECTIVES

After completing this chapter, you will be able to:

1. Identify the components of the central processing unit
2. Describe what occurs during a machine cycle
3. Explain how main storage differs from secondary storage and the purpose of each
4. Differentiate between multiprogramming and multiprocessing
5. Describe the purpose of an operating system and compare several current ones

OVERVIEW

In the Overview in Chapter 2, an inventory clerk updated the inventory manually. You saw how he input and output the data, but how does he process it?

The clerk compares the item number of an entry on the receipt list to the item number of an entry on the current inventory. If the inventory's item number is not the same as the receipt's item number, the clerk does not update it but continues to look for the matching inventory item. When the item numbers match, he adds the number received to the current inventory balance. Thus he performs the two functions expected of a computer's processing unit: logical decisions and mathematical calculations. How the computer performs these two functions is the subject of this chapter.

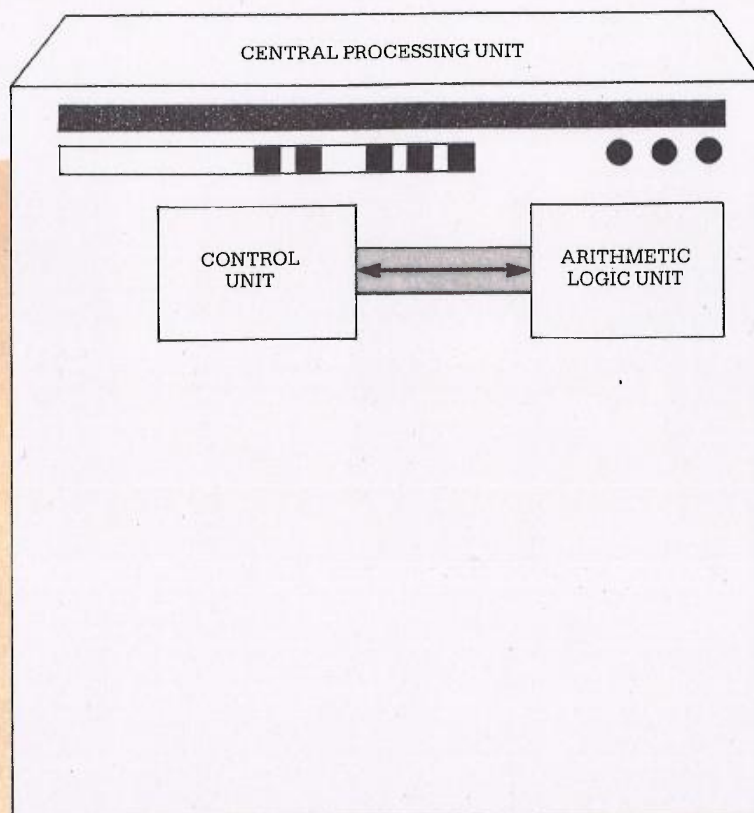


Central Processing Unit

The **central processing unit**, also called the CPU, is the hardware that performs the processing functions. It has two parts, the arithmetic/logic unit and the control unit. Housed within the same physical device is the internal storage unit, also called *main memory*, or *primary storage* (Figure 3.1).

Arithmetic/Logic Unit

The **arithmetic/logic unit (ALU)**, as the name implies, contains all the circuitry necessary to perform the computer's arithmetic and comparison op-

**Figure 3.1**

The central processing unit consists of the arithmetic/logic unit and the control unit.

erations. It can calculate or round off numbers, compare algebraically or logically, and so on. For example, if you write the instruction "add A to B," the ALU performs the addition.

Control Unit

The **control unit** directs the activities of the computer. It also controls the activities of the input/output units as instructed by the programs. The control unit transfers data and instructions between the ALU and main memory. In general, it controls the flow of data within the system.

Internal Storage

Internal storage, also called **main memory** or **primary storage**, contains the data and instructions being processed after they have been received from the input units. Data and instructions must be stored within internal storage

before being processed, since this is where the control unit will look for them (Figure 3.2).

Several types of internal storage are available. The two most common are random access memory (RAM) and read-only memory (ROM).

Random Access Memory. The part of storage that holds programs and the data they use is called **random access memory**. RAM's contents are easily changed; in fact, they change constantly during the execution of a program as new data is read and processed.

Read-Only Memory. A second type of internal storage is called **read-only memory** because its contents can only be read, not altered. These contents are loaded once, usually by the computer's manufacturer. ROM is used to hold these instructions meant to remain in memory storage permanently.

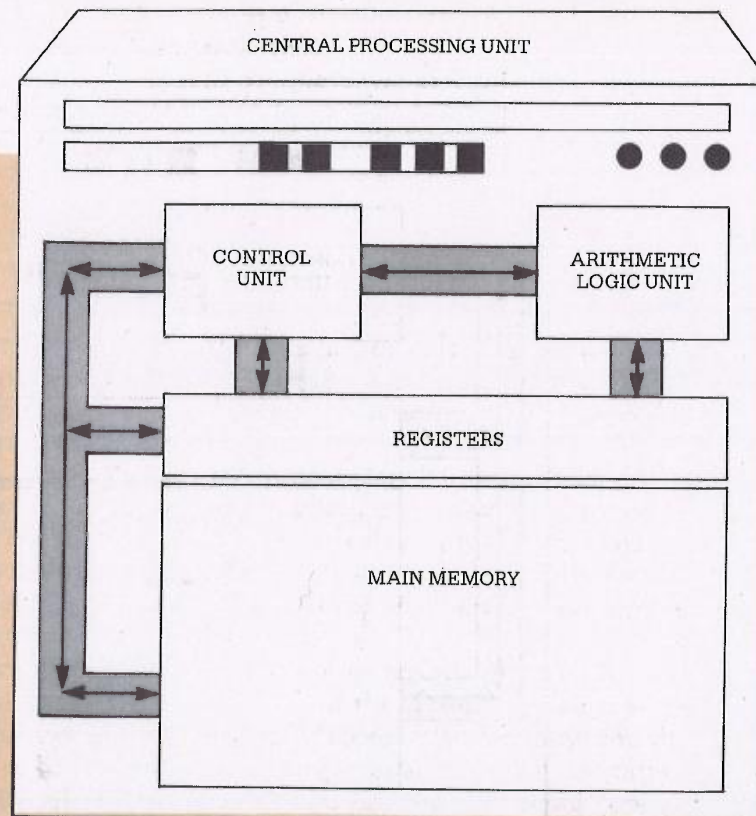


Figure 3.2

Data and instructions must be located in internal storage before they can be processed. Registers serve as high-speed access areas between internal storage and the CPU, where the instructions are processed.

This would include parts of the operating system, such as those programs that control computer operations, regardless of which user program is running. It might also include a **compiler**, a program used to translate a program written by the user into the computer's language so that it can be executed (more on languages later).

Registers

Linking the CPU and internal memory are several storage locations called **registers**. They are used to hold data and instructions temporarily during a program's execution. Since the contents of registers can be quickly located and retrieved, data and instructions are normally moved from main memory to a register just before they are processed.

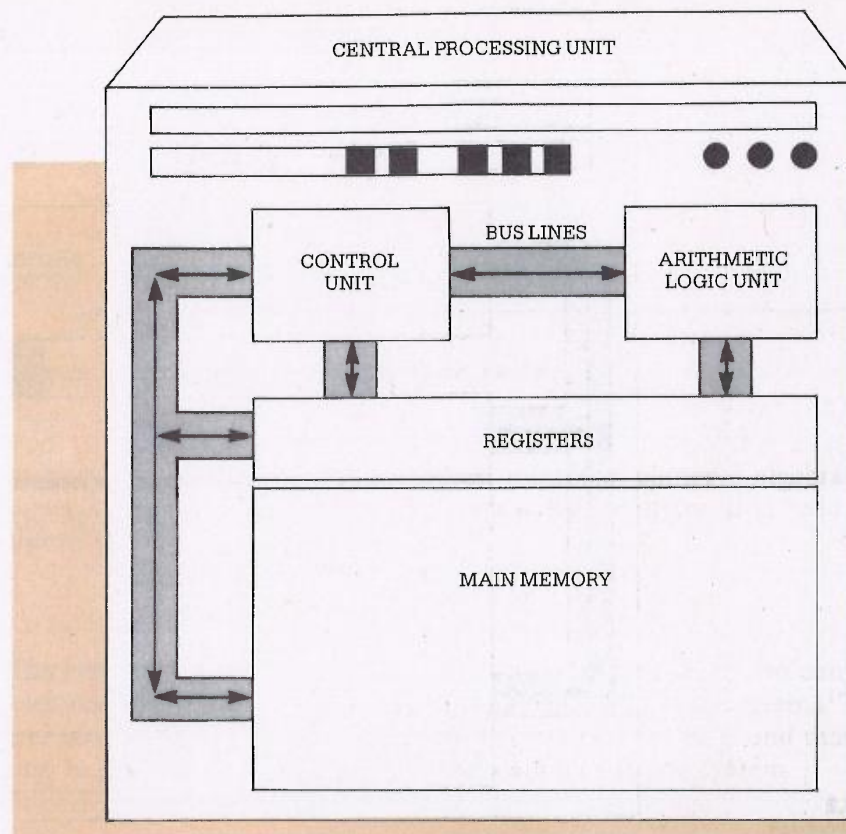


Figure 3.3

Although the registers link internal storage and the CPU, they are just holding areas. The data and the instructions are transferred within the computer via channels that carry electrical signals. These channels are called *bus lines*.

Bus Lines

Bus lines, special electrical cables, are the physical connection linking main memory, the registers, and the CPU (Figure 3.3). The CPU, registers, and main storage work together to enable a program to be run. The easiest way to see how these various components work together is to walk through one machine cycle in detail.

The Machine Cycle

A **machine cycle** (Figure 3.4) consists of the series of operations necessary to execute a single machine language instruction. This cycle is divided into two parts, **instruction time (I-time)** and **execution time (E-time)**. I-time is the time necessary for the control unit to pull an instruction from main memory and prepare it for processing. E-time is the period required to locate the data needs, execute the instruction, and store the results in main memory.

The time needed to complete one machine cycle depends on the computer being used.

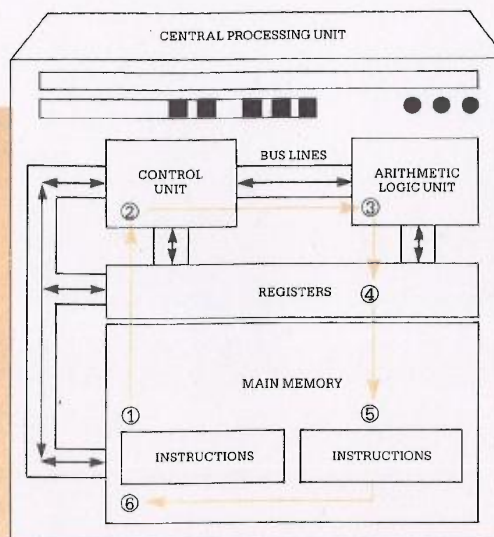
Processing Techniques

As Figure 3.4 shows, to execute a single machine language instruction, the computer must fetch, translate, pass control, execute, and store. How does the computer know which of these activities to perform? How does it start? What makes it work?

A computer with all the necessary hardware still needs something else to make it work: **application programs**, which instruct the computer what to do. These programs determine whether inventory, payroll, or something else is to run, but they do not provide all the details about how to run it. Another group of programs serves as a go-between for application programs and hardware.

For example, consider a simple request to read a record. The programmer asks that a record be read. If the record is to be read from a tape, the tape must be started, the record copied into memory, and the tape stopped. If it is to be read from disk, the access arm mechanism must be moved, the correct read/write head switched on, and the record copied into memory. The programmer does not give these detailed instructions on *how* to read the record. These instructions are a part of the programs that make up the operating system.

The **operating system** is a series of programs designed to manage resources: hardware, other software, and data. (Software comprises the pro-



In I-time, (1) the control unit fetches the next instruction to be executed from the CPU; (2) it interprets what this instruction is to do and where the needed data are located; and (3) it passes control to the arithmetic/logic unit.

In E-time, (4) the ALU executes the instruction and returns control to the control unit; (5) the control unit stores the data in main memory, if necessary; and (6) it now returns to step 1 to locate the next instruction.

Figure 3.4

Outline of a machine cycle.

grams that run the computer system.) Its purpose is twofold: to make it easier to use the hardware and to allocate the computer's resources efficiently among the various users.

There are two measures of how efficiently the resources are used. The first, **throughput**, is the amount of processing that occurs in a given period. The second measure is called **turnaround**; this is the elapsed time between job submission and output receipt.

The speeds at which data is processed have increased dramatically during the past few years. However, improvements of speeds of peripheral devices have been much less dramatic. This has led to a significant speed disparity between the CPU and the peripheral devices. For example, calculating the amounts on a paycheck is much quicker than printing those amounts on the check itself. Buffers, spooling, multiprogramming, and multiprocessing are all used to improve efficiency.

Buffers

Buffers are storage areas used to collect data as it is transferred into or out of memory from the peripheral devices. However, if the computer had only one buffer, it would have to wait for the data to be moved into the buffer from the peripheral device before it could process the record. The use of multiple buffers improves efficiency.

For example, suppose a program is supposed to read records from tape, and now two buffers are present instead of one. As the program begins, it waits for the first buffer to be filled before beginning processing. While the record in the first buffer is being processed, however, the second buffer is being filled. When a second "read" instruction is issued, the record in the second buffer is processed at the same time the first buffer is being refilled (Figure 3.5). As the record is being processed, other buffers are being refilled

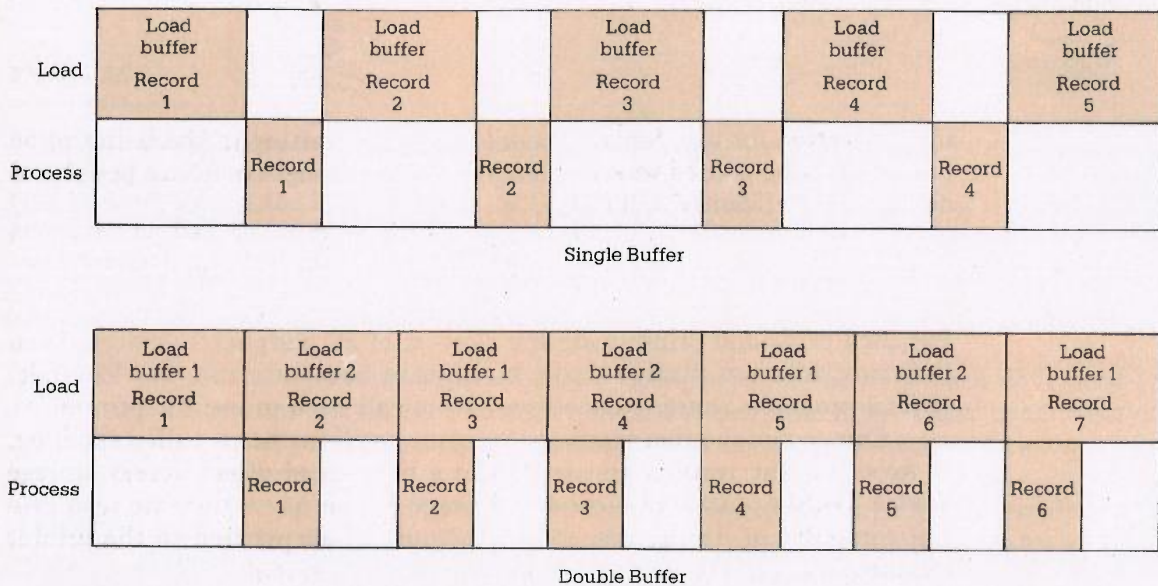


Figure 3.5

The introduction of multiple buffers significantly decreased idle computer time because one buffer can be refilled while the records in another buffer are being processed.

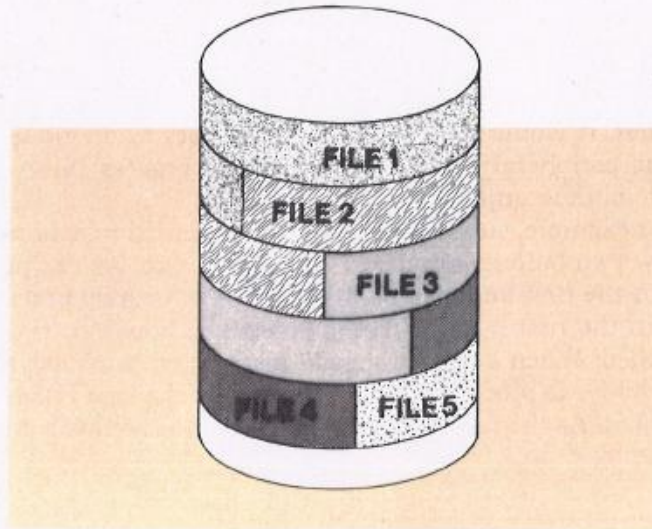


Figure 3.6

Spooling of print files means the files are stored for printing later. One program can produce many printed reports, even if the shop has only one printer, because the reports can be printed individually later.

in preparation for use. Since a record is usually waiting in the buffer to be processed, time wasted waiting for a record to be brought in from a peripheral device is significantly reduced.

Spooling

Punched cards and printers are the slowest of all peripheral devices. Even buffering does not always result in efficient computer use. For example, several programs running concurrently may all need to use the printer.

One technique that increases efficiency still further is called **spooling**. In spooling, the records are written to a high-speed **direct access storage device (DASD)**, a type of secondary storage device. Later they are read into the computer or, in the case of printed output, are written to the printer (Figure 3.6).

Multiprogramming

Buffering and spooling have increased machine efficiency, but idle time is still a problem. One program may not use all the peripheral devices; some devices sit idle while that program is running. A program may also waste time waiting for data to be transferred into main memory.

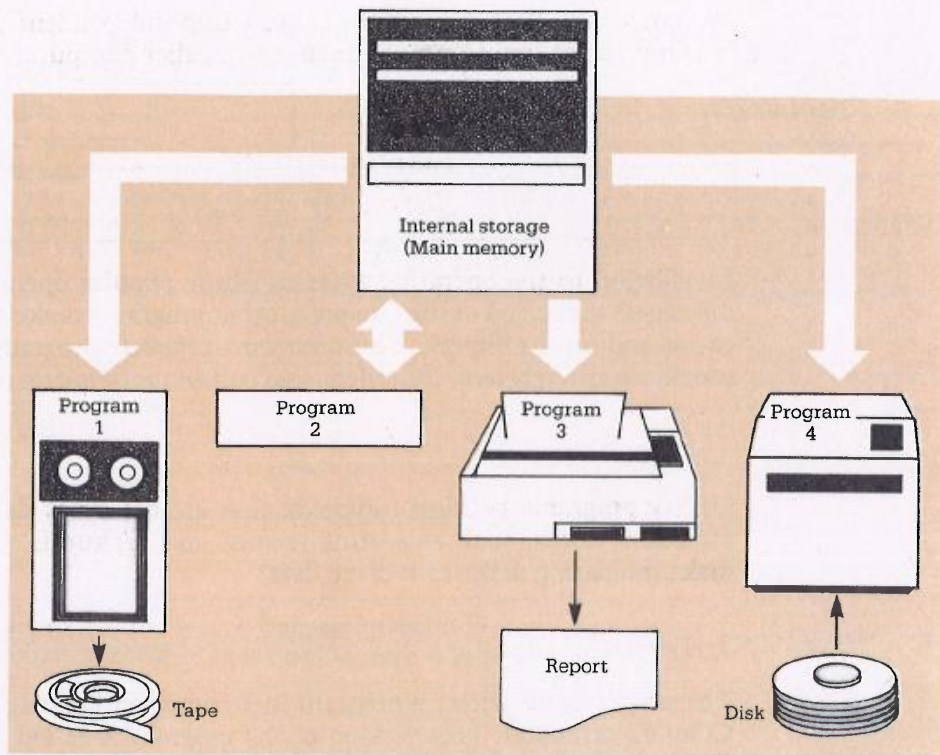


Figure 3.7

Multiprogramming permits several programs to share internal storage and CPU services at one time. Program 1 may be writing to tape, program 2 using the CPU, program 3 printing a report, and program 4 reading data in from a disk, all apparently simultaneously.

To reduce this idle time, operating systems have been developed to utilize the CPU and the peripheral devices more fully. These operating systems permit **multiprogramming**, the concurrent execution of two or more programs.

In multiprogramming, the time wasted waiting for the completion of an input/output operation is now spent processing another program's data. When that program needs more data, no idle time occurs; another program uses the available processing resources of the CPU (Figure 3.7).

Multiprocessing

Whereas multiprogramming is the concurrent execution of more than one program by the same processor, **multiprocessing** is program execution by more than one processor; two or more instructions can be executed si-

multaneously. Each processor may function independently, permitting the farming out of input/output functions or other computer activities.

Other Systems Software Features

In addition to the operating systems (some popular operating systems are discussed at the end of the Chapter), other programs make using a computer easier and more efficient. These systems software programs include utility programs, interpreters, compilers, and performance measurement programs.

Utility Programs

Utility programs perform functions that almost every data processing installation needs, such as sorting records and backup files and initializing disks (preparing disks to receive data).

Interpreters

The programmer writes a program in a computer language such as BASIC, COBOL, or Pascal. This version of the program is called a **source module**. Since the computer can execute a program only when that program is in the computer's machine language, the source module must be translated before the program can be run.

An **interpreter** is a program that reads one of these source language instructions and translates it into machine language. Once this instruction is translated, it is executed. The next instruction is then translated and the cycle repeated.

Interpreting a program saves space on the program library because the program is translated each time it is run. The program takes longer to run, however, since it must be interpreted each time it is executed. Interpreters are most effective when the program is not to be run regularly.

Compilers

A **compiler** is also a program. It takes the entire source language module and translates it into a machine language version called an **object module** (Figure 3.8).

Whereas the interpreter translates only one instruction before the computer attempts to execute it, the compiler translates the entire program before execution is attempted. Compilers are most useful when a program is to be run regularly, since the compiler has created a machine language version of the whole program—the object module—no time is wasted retranslating the program each time it is run. Additional library space is

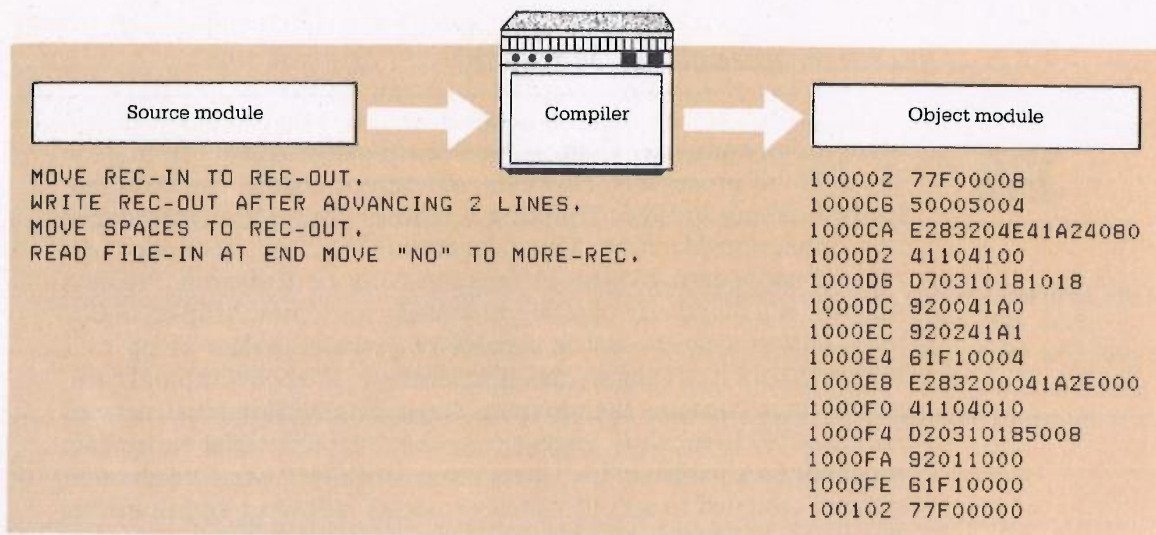


Figure 3.8

During the compile process, the source language program is translated, and an object module in machine language is generated.

used, however, since the object module must be saved. (Languages are discussed more extensively in Chapter 4.)

Performance Measurement Programs

A student's performance may be measured by grades, a car's performance by miles per gallon. The computer system's performance is reported and analyzed by **performance measurement programs**. For example, a computer operations manager might want to know what percentage of time the CPU was used, how many times a printer was written to or a disk read, or how many errors occurred as a disk was written to. These questions are all answered by the performance measurement software. This software records performance activity and provides information on system and peripheral device use.

Some Popular Operating Systems

There are many operating systems in use today. Some of the popular ones include OS-MVS, CP/M, MS-DOS, and Unix. OS-MVS was designed to run on mainframe computers, CP/M and MS-DOS on microcomputers. Unix is



The Connection Machine

Many microcomputer changes have involved increasing from 8- to 16- to 32-bit processors. However, one recent change has been radically different. In 1986, Thinking Machines Corporation introduced its Connection Machine. The Connection Machine, developed in a project sponsored by the Defense Advanced Research Projects Agency, is a massively parallel processing computer. It links 16,000 to 64,000 processors and is capable of processing data at up to 1 billion instructions per second. The front end is a conventional computer which contains the program. Single data-element instructions are executed here while instructions that operate on the entire data set at once are passed to the Connection Machine. Each data element is there assigned to an individual processor, allowing simultaneous execution by thousands of processors.

run on all sizes of computers except for the smallest microcomputers. Each operating system is described in terms of the word size of its microprocessor: usually 8 bits (binary digits), 16 bits, or 32 bits (see *On the Job*). Typically, a word is the amount of data that is contained in one register and that is moved across the bus lines at one time; the bigger the word, the more data that can be moved in parallel across the bus line and thus the faster the machine. A bigger word also accommodates larger addressable memory locations, more machine language instructions, and greater accuracy and efficiency in manipulating numbers in the registers.

OS-MVS

OS-MVS (Operating System-Multiple Virtual Storage) was designed by IBM for its 370 series **mainframes** (mainframes are the largest, fastest class of computers). It handles multiprogramming in a virtual memory environment.

In **virtual memory** a program to be executed is stored on a DASD device, usually a disk, and divided into segments called **pages**. These pages are moved into main memory as they are needed. Since all parts of a program are not needed at the same time, this permits more programs to reside in main memory simultaneously and improves throughput.

MS-DOS

MS-DOS, or MicroSoft Disk Operating System, was developed by Microsoft, Inc. It is a leading operating system in the microcomputer market. The most

popular 16-bit system, it is designed for computers that support only one user at a time. MS-DOS can be used on many small computers.

Many versions have appeared since MS-DOS was first published, each more powerful than its predecessor. MS-DOS can now support many high-level languages and handles disk input/output very efficiently.

CP/M

In the mid-1970s, Digital Research developed CP/M (Control Program/Microcomputers) for 8-bit systems. A newer release, CP/M86, has been developed for 16-bit systems. Many microcomputer suppliers, under a licensing agreement from Digital Research, sell a version of CP/M for their own systems. CP/M is a popular system, so many programs designed to run under it are available commercially (Figure 3.9).

UNIX

Unix, developed at Bell Laboratories in 1969, is a general purpose system that supports several terminals. Since it is portable—able to be moved from one machine to another—application programs written for one machine using Unix can be moved to another with minimal effort.

Designed to handle multiusers handling many tasks, Unix resources can be shared among several users. Because Unix began as a programmer tool, many of its commands resemble programming instructions. Thus it has a reputation for being difficult for non-data processing personnel to use.

Unix is widely available. Although it requires a relatively large system by microcomputer standards, it is currently available for micros, minis, mainframes, and even supercomputers.

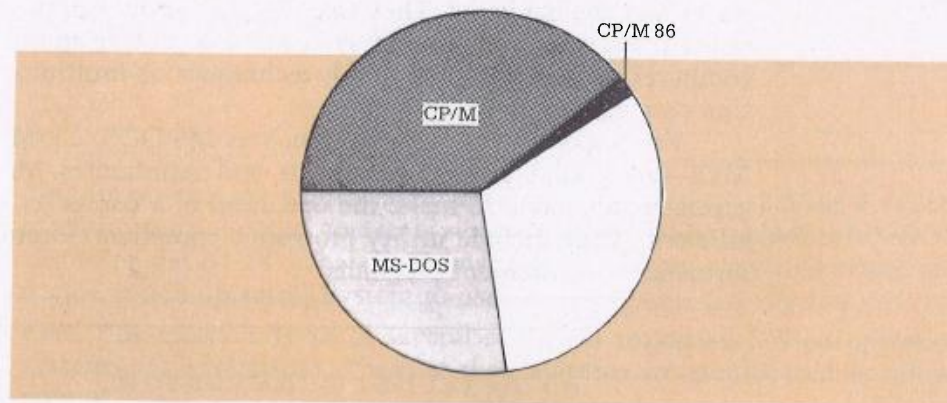


Figure 3.9

In 1983 CP/M had a 39% share, Microsoft's MS-DOS a 30% share, and CP/M-86 a 3% share of the business operating system market.

Criteria for Evaluating the Operating System

All operating systems cannot run on all computers, but many computers can use one of several operating systems. Several factors must be considered when choosing an operating system.

Operating systems are evaluated first in terms of what they do. Does the operating system do what you need to have done? If several operating systems can perform at the level you need, other considerations include:

1. How much memory does the computer have, and, of this memory, how much will the operating system use?
2. How easy is the system to use?
3. Is the system well documented; that is, are the accompanying instructions or user's manual easy to understand?
4. How secure is the system? Is one user safe from another's activities?
5. In what language is the operating system written? If it is written in a high-level rather than a machine-level language, it is probably portable.
6. How easy will it be to upgrade and install a larger, more powerful system?

Summary

The central processing unit runs the computer. It consists of the control unit and the arithmetic/logic unit. The control unit directs the activities of the computer system, whereas the ALU performs all the necessary arithmetic and logical functions. Other parts of the computer hardware include registers and bus lines.

Operating systems provide an interface between the application programs and the hardware. They free the programmer from coding many detailed instructions. Operating systems also provide more efficient use of computer resources through such techniques as multiprogramming, multiprocessing, and spooling.

Various operating systems—such as MS-DOS, CP/M, Unix, and OS-MVS—are available for micros, minis, and mainframes. Many types of programs are available to make the operation of a computer easier and more efficient. They include utility programs, compilers, interpreters, and performance measurement programs.

AT XFIELDS: CONCLUSION

Anne picked up her note pad. The new equipment had arrived; now it was time to begin the training sessions.

Using Unix on both the old and the new systems had made transferring existing programs easy. The old users would notice few changes. She hoped that the new users were looking forward to getting on the terminals. Usually at least one person at each session stared at the terminal in sweaty-palmed terror, afraid to touch a key.

"I suppose some of that's our own fault," she thought. "We talk about systems 'crashing,' programs 'blowing up,' and jobs being 'killed.' Maybe they really believe that's what happens." She smiled, picked up her coffee and notes, and headed for the conference room.

Exercises

1. What are the two main parts of the CPU? What is the purpose of each?
2. Explain the difference between ROM and RAM. What is the purpose of each?
3. What is the purpose of a register? Of a bus line?
4. Describe the steps required to execute a machine instruction.
5. Why is an operating system so useful?
6. What programs measure machine efficiency?
7. Define spooling, multiprogramming, and multiprocessing.
8. Why are utility programs provided?
9. What is the difference between an interpreter and a compiler?
10. Describe some characteristics of the four operating systems discussed: UNIX, MS-DOS, CP/M, and OS/MVS.

Projects

1. You are purchasing a microcomputer. It will be used for running a variety of applications. Several operating systems are available, including MS-DOS, CP/M86, and UNIX. What questions might you want answered before you decide which operating system to use?
2. Read this month's issue of several computer magazines. What operating systems are advertised? Which of their features are emphasized as selling points?

Microcomputers

AT XFIELDS, INC.

Pat had been watching the microcomputers arrive. She wasn't involved in data processing at Xfields, but her children had been asking if they could get a computer for home. Some of the other children had them, and the teachers had praised the neatly typed papers produced on the computers. That was the reason her daughter Sara and son Bill had given for wanting one. She expected that the games that could be purchased to use on a home microcomputer might be as much an incentive as better grades on their school work.

How do I decide what to buy? Even if I could buy one, Pat thought, could I ever learn to use it? Would the children use it after the first few weeks? She would have to answer many questions before she decided whether to buy one.

Pat decided her next step would be talking to some of her friends who owned micros and her fellow employees who worked with computers.

CHAPTER OBJECTIVES

After completing this chapter, you will be able to:

1. Discuss the history of the microcomputer revolution
2. Describe the unique hardware characteristics of the microcomputer
3. Explain what a "supermicro" is
4. Discuss the various uses of microcomputers
5. Evaluate microcomputer hardware
6. Evaluate software
7. Know how to care for the microcomputer system

OVERVIEW

A child learning her multiplication tables, a farmer in the midwest calculating optimal feed mix for his cattle, a small business owner tracking her accounts receivable, a teenager playing games, a house whose environment is being automatically monitored—what do they have in common? A microcomputer is at the heart of each of these activities.

Since 1976, microcomputers have grown into a multibillion dollar business (Figure 6.1). In 1984, almost 4 million computers were sold for home use. By 1989, the market is projected to exceed 15 billion dollars for microcomputer software alone.



Brief History of Microcomputers

In 1971, Texas Instruments demonstrated the first fully operational microprocessor, a processor on a single silicon chip. Since then, microprocessors have been used in such diversified products as ovens, cars, and televisions.

Microcomputers, computers whose processing component is a microprocessor, have been available since 1976. At that time Altair sold the first microcomputers in build-it-yourself kits to hobbyists and electronic buffs. This microcomputer did lure the hobbyist, but it did not attract many people who wanted to use a microcomputer but were not interested in the electronics of building one.

A second revolutionary event occurred in 1976: Stephen Wozniak, a



Figure 6.1

Microcomputers have become a vital part of many homes, schools, and businesses (photo courtesy of Hewlett-Packard).

young hobbyist who worked for Hewlett-Packard, built a small computer. His friend Steve Jobs, who worked for Atari, also saw the value of this computer. Small and inexpensive enough for the general public to buy and use, these "ready made" computers could be made available to those who lacked the skill or interest to build their own. By 1982, the revenues of Apple, Inc., exceeded 650 million dollars.

Apple, Inc., was not alone in the microcomputer market. Commodore also introduced a microcomputer in 1977, the PET. The PET was a 4 K machine that could be programmed in the BASIC language. It used a cassette tape as secondary storage and was also designed for the general public.

Microcomputer Characteristics

Microcomputer sales are still booming. What are the characteristics of these machines?

Hardware

A person could easily identify a microcomputer a few years ago, describing it by price, amount of internal storage, and designation for operation by one user at a time. Now prices are falling, internal storage is being increased to amounts unanticipated, and some microcomputers are designed to serve more than one user at a time. What then is a microcomputer?

A **microcomputer** basically is a computer built around a single **microprocessor chip** (Figure 6.2). This single chip contains the arithmetic/logic unit (ALU), the control unit, and the primary storage unit. In addition to this chip, the computer has internal storage and facilities for some type of input/output—usually a keyboard and a video monitor. Also called *personal computers* (PCs), microcomputers can vary from pocket to desk top size. Auxiliary storage may be on cassette tape but more often is on floppy or hard disk.

Software

Hardware is only a part of the microcomputer system. What about the software: the operating system and applications software?

Operating System. The **operating system** controls the software running on a computer and the hardware that comprises the system. It permits the operators to interact with the computer, allowing them to start and stop programs running on the system. It also enables the system to send messages to the operator. For example, "printer not ready" might appear if the user requested printed output without turning the printer on and stocking it with paper.

The typical microcomputer user is not a professional computer operator; often the microcomputer was purchased to do a job. This task is the important factor; the user wants to do it as quickly and easily as possible. Thus the operating system makes the computer easy to operate. The system commands—such as "lock," "delete," "rename," "run," "save," "load," and "unlock"—are logical, English-like, and easy to learn.

The operating system of most microcomputers enables only one person to use the system at a time. However, **supermicros** have been developed that can "multitask"; that is, they have the ability to run more than one program at a time. These multiuser microcomputers are made up of several work stations that share the same microcomputer and peripheral devices. Each work station consists of a keyboard and monitor. While a secretary uses one workstation to create a letter, an accountant might use another station to create a spreadsheet, and a different operator might use one to test a BASIC program.

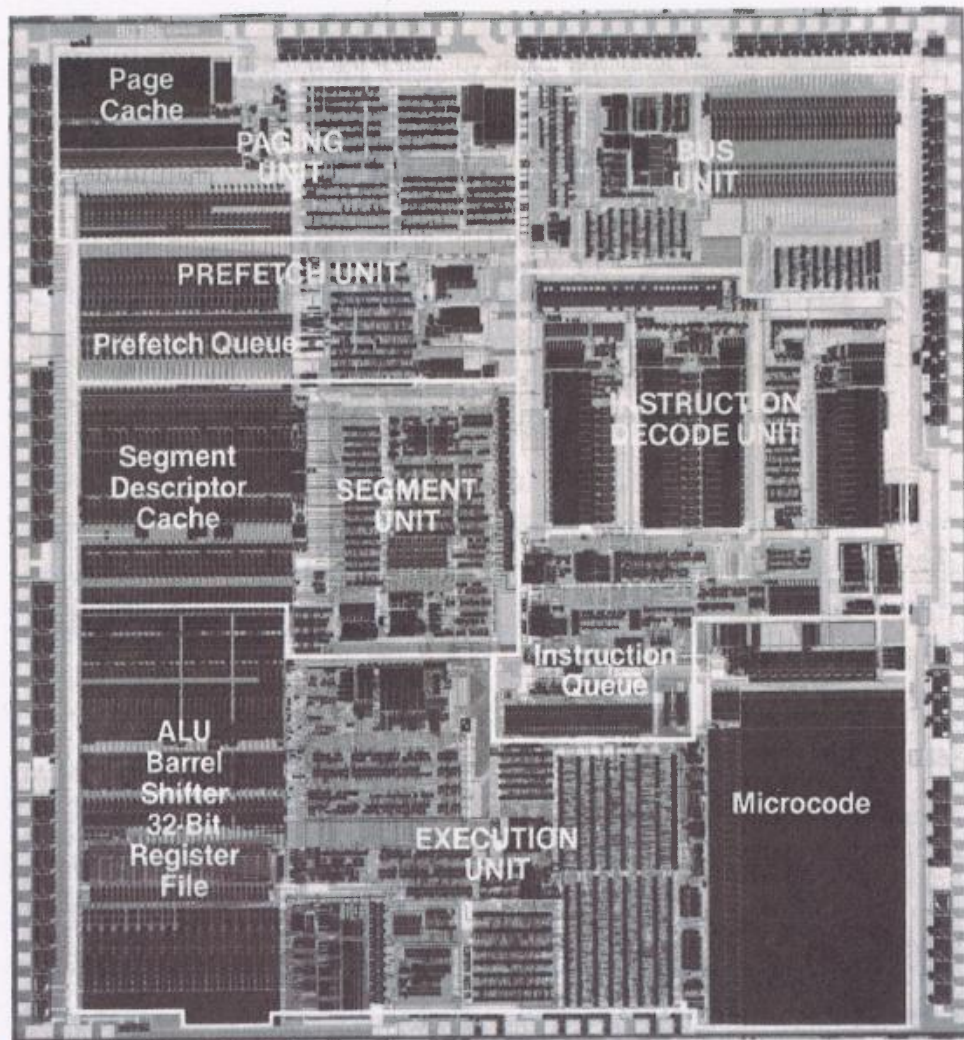


Figure 6.2

A microprocessor chip contains the ALU as well as the control unit for a microcomputer (photo courtesy of Intel Corporation).

Applications Software. Microcomputer software is as varied as its users. Among the most popular software is word processing, database management, electronic spreadsheets, graphics, and communications. Integrated software, which performs multiple functions, is also extremely popular. Integrated software makes using a microcomputer even easier by allowing the user to take information created in one application and pass it to another

application for use. A manager might create a spreadsheet and then pass the information contained in the spreadsheet to the graphics portion of the integrated package for conversion to a graph. Later, a secretary may pass the spreadsheet or graph over to the word processing program for inclusion in a memo or other document (see also Chapter 4).

Database management, graphics, spreadsheets, and word processing are discussed in detail in Chapter 8; telecommunications is discussed in Chapter 10.

These microcomputers, originally viewed as a toy for the hobbyist or as a small, inexpensive computer for the individual user, have become much more important. Do you want a device to monitor the environment of your home, control heat and lights, and notify you that your lawn needs mowing or watering? Your microcomputer can do it with a sensor (Figure 6.3). Do you want to play games, but no one is home tonight? Play against your microcomputer. Do you want to keep the books for a small business or records for a group? Keep them on your microcomputer.

Today, microcomputers are used in many locations, both likely and unlikely (see *On the Job*). Individuals and small businesses typically use them. Large companies use them either as stand-alone computers or as part of data networks. Linked to a mainframe computer as part of a network, the microcomputer may be used as a "dumb" terminal. It may also serve as an "intelligent" terminal; data may be downloaded from the mainframe to the microcomputer and processed there (see Chapter 2, Input Devices and Media).

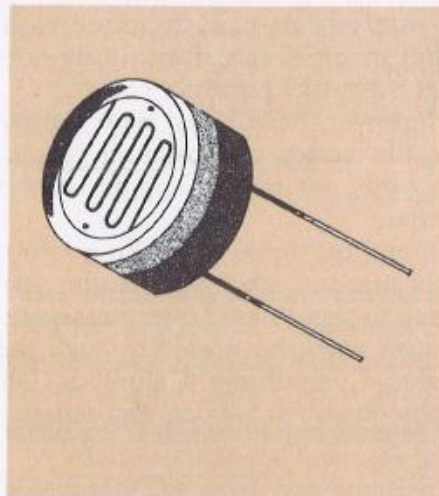


Figure 6.3

Input to a microcomputer can be through sensors as well as through keyboards.



A Very Portable Portable

On February 27, 1984, sixteen men began to climb Mt. Everest in Tibet. They were attempting to retrace a route travelled unsuccessfully in 1924 by a group of British climbers. A part of their survival equipment was a Multipersonal computer capable of functioning in any weather from 0 to 40 degrees below zero. The computer was used to keep track of inventory and help choose the best route to the summit by analyzing such variables as snowfall, temperature, energy consumption, and available equipment. It also was used to monitor the expedition members' health.

Adapted from Korzeniowski, Paul.
Computerworld, March 5, 1984, p. 26.

The Users

As noted, individuals, educators and other professionals, small and large businesses, and many others employ microcomputers.

Individuals

Games have given way to word processing as the prime reason for purchasing many microcomputers, but many of us still try to fly our starships or try to outwit the computer at maze-like games or chess.

Many individuals, however, have found new computer tasks. They balance their checkbooks, file recipes, plan balanced menus, count calories, write letters, and design cards, invitations and announcements with the help of their microcomputer.

Finally, they have found the value of hooking into commercial networks, such as bulletin boards and other information services. Electronic **bulletin boards** can be used to post or exchange messages. The home computer can put one "in touch with the world" through the Dow Jones Information Retrieval Service, CompuServe (Columbus, Ohio), The Source (McLean, Va.), Bibliographic Research Service, and others.

Educators

Do you know anyone who teaches basic skills: defensive driving, basic reading, or math? What about teaching typing, physics, history, logic, wilderness survival, human anatomy, Spanish, algebra, Latin, geometry, human sex-

sexuality, or how photosynthesis really works? Microcomputer **courseware** is available on all these and many more subjects.

Computer aided instruction (CAI) uses computers to teach material. Although outside programmers develop most CAI material, many teachers are beginning to develop their own material using specialized, high-level programming languages such as TuTor.

Material may be presented as **drills** in which little or no new material is presented. The student learns the contents by repeating them over and over, much as you once learned the multiplication tables. New material may also be presented in **tutorials** and the student then drilled on the contents. A third way CAI may teach is through **simulations**, imitating the process to be learned under the student's control, a method used in teaching flying.

Because the computer is interactive, the student's skill level can influence the material presented. Wrong answers may result in a review of material, whereas continued correct answers may cause a jump to more difficult material. Provided the computer courseware is relevant to the course, is sequenced properly (long division is not taught before addition), and is clear and appropriate in its feedback to the student, excellent results may be obtained.

One question can always be answered about the best courseware: Why not use a book, a lecture, or a film? The microcomputer should provide something not available from other media, such as the ability to proceed at one's own speed or to simulate potentially dangerous situations without exposing the inexperienced student to actual danger (Figure 6.4).

Microcomputers are also used for administrative purposes. Many schools are using automated telephoning to check on absentee students. Tests and crossword puzzles are automatically generated by computer (Figure 6.5); library catalogs are maintained; class rolls are kept; and gradebooks are averaged and graphed by computer. Even the reading level of material may be automatically calculated by keying in a brief selection from the material to be evaluated.

Small Businesses

Small businesses perform almost all the functions of a large business; they keep payrolls and the associated tax records, maintain and evaluate an inventory, and generate written communications such as letters and reports. They may also create signs announcing future sales and promotions and graphs. A microcomputer can assist in the performance of all these tasks.

Many specialized business functions are also available for the microcomputer. The small construction business may use packaged programs in generating a bid, or a dairyman may decide how to cull his herd based on computerized records (Figure 6.6).

Microcomputers are used to keep medical records, locate lost dogs,

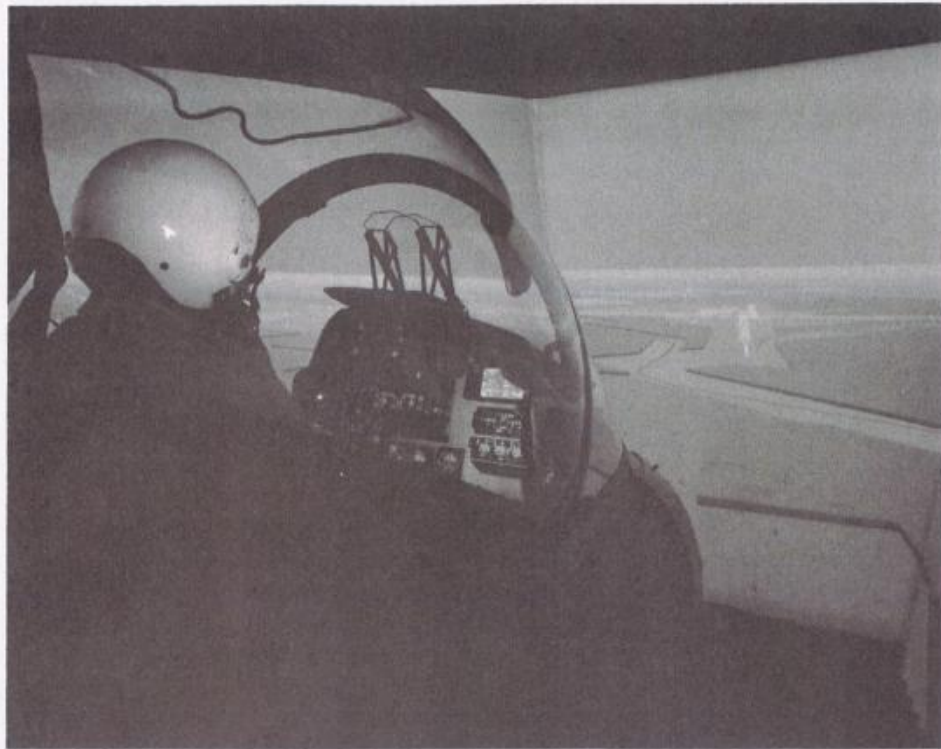


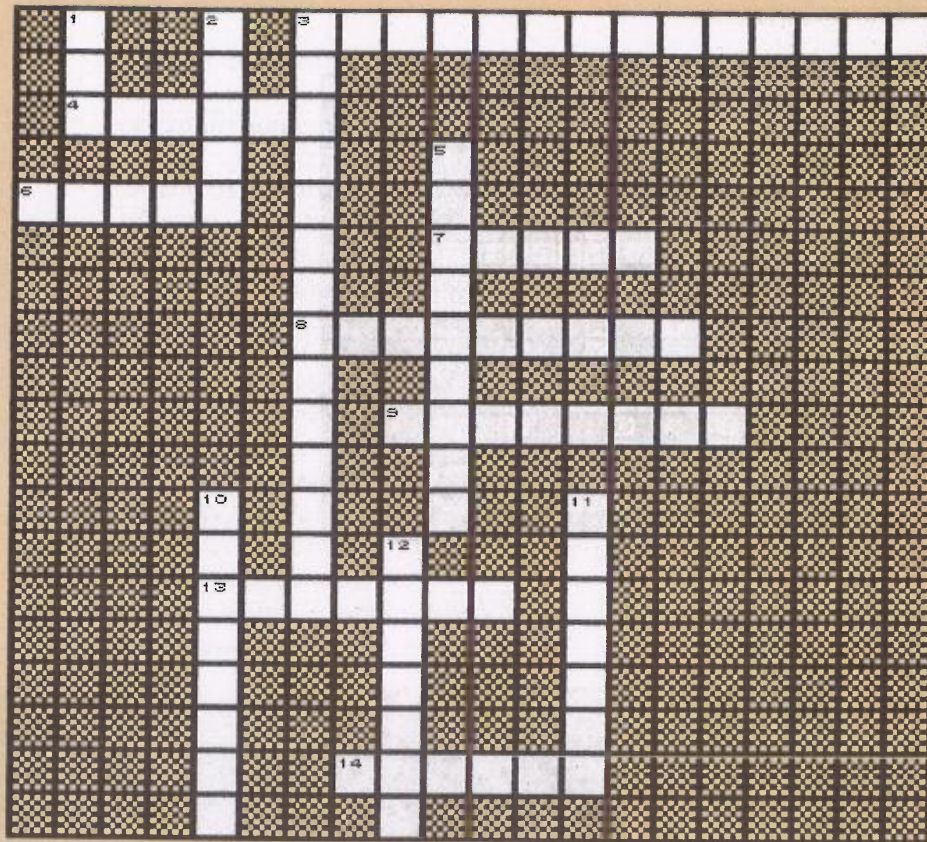
Figure 6.4

Preparing to land on a computer-generated airfield, this U.S. Marine Corps pilot is getting valuable training in the McDonnell Douglas AV-8B Harrier II operational flight trainer. The trainer does everything the short-takeoff and vertical-landing (STOVL) AV-8B does—turns, climbs, rolls, hovers—without taking the new pilot off the ground (courtesy of the Public Relations Department, McDonnell Douglas Corporation, P.O. Box 516, St. Louis, MO 63166).

maintain flight logs, monitor stock portfolios, and maintain real estate information.

Large Businesses

John V. Roach, chief executive officer of Tandy Corp./Radio Shack, delivered the keynote address at the Data Processing Management Association meeting in Anaheim, California in 1984. In that address he said, "The time taken to define an optimum solution may, in fact, be too long to permit an optimum solution. . . . Fortunately though, a highly satisfactory solution can be arrived at by those who understand the alternatives and who react quickly and decisively. . . ." He was speaking of the productivity gains made pos-



ACROSS CLUES:

- 3) a processor-on-a-chip
- 4) the first commercially available electronic computer
- 6) a general-purpose language developed at Dartmouth for student use
- 7) a language developed for business use by representatives of government and industry
- 8) a term for large computers
- 9) the physical components of a computer system.
- 13) an early scientific language
- 14) a high-level language named for a seventeenth-century French mathematician

DOWN CLUES:

- 1) another name for the arithmetic/logic unit
- 2) the first computer to use the stored program concept
- 3) a term describing the smallest class of computers
- 5) storage that is not a part of main memory is sometimes called _____ storage.
- 10) the programs used on a computer are called _____
- 11) the part of the central processing unit that directs the execution of instructions is called the _____ unit
- 12) the step-by-step instructions that direct the computer

Figure 6.5

This crossword puzzle, reviewing some data processing terms, was computer generated and used in an Introduction to Data Processing test.

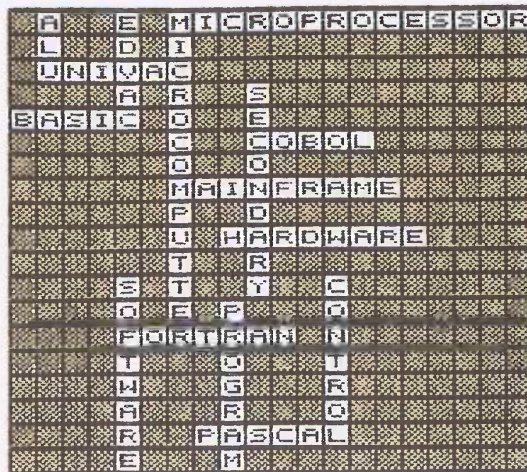


Figure 6.5

(continued)



Figure 6.6

Many small businesses keep computerized records. The ability to show information graphically makes the information more readable (photo courtesy of Hewlett-Packard).

sible by technological advances, but he could as well have been describing the everyday problem of any manager: how to make a decision in the face of rapidly changing circumstances.

A major problem in business has been that the data processing department can provide the information needed, but business needs the answer *now*, not six months later when data processing can produce it. For many businesses, microcomputers have provided a partial answer to this problem. As a stand-alone device, the microcomputer provides computing power where it is needed—at the user's desk.

The great drawback of the stand-alone microcomputer is that the power is provided but often not the data. The information needed may be located at the mainframe. Interaction with the mainframe as part of a network gives the microcomputer both the power and the data (Figure 6.7).

Easy access to data, however, carries problems of data security and integrity, as well as possible communication conflicts. Despite these problems, data networks, varying in size from room-sized to global networks, are mushrooming.

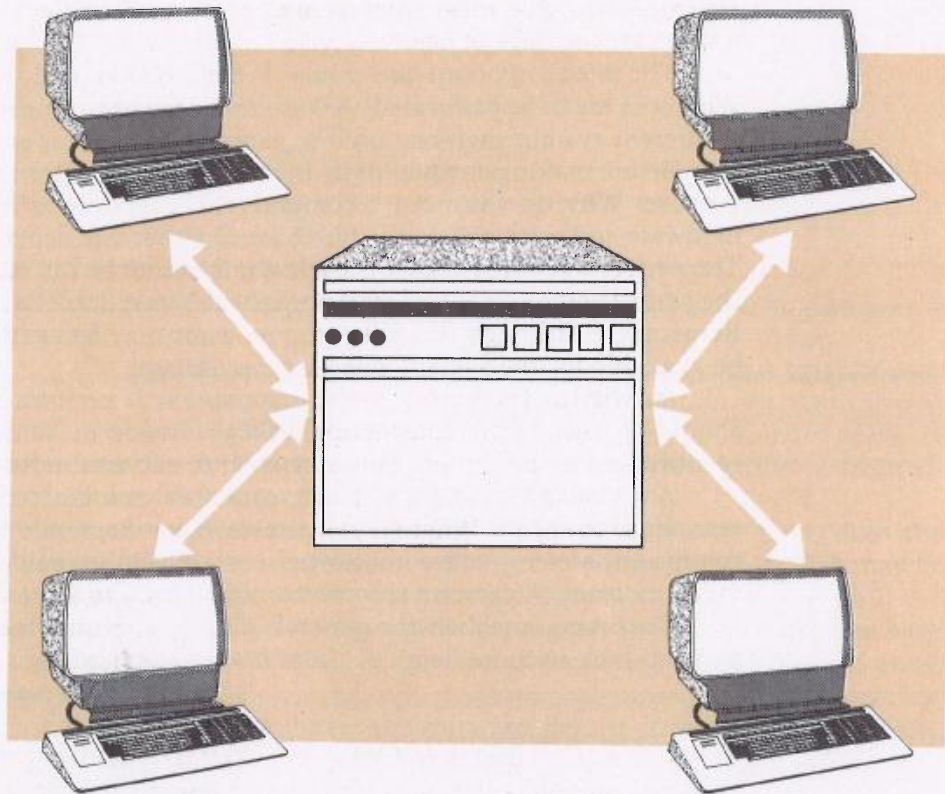


Figure 6.7

Networking with microcomputers puts the resources of the mainframe on the desk of the user.

Criteria for Selecting and Evaluating a System

Have all the possible uses discussed so far made you long to run out and purchase your own microcomputer? You could use the spreadsheets for work, the word processing for your research papers and club newsletters, and other software to maintain your budget or mailing lists for a small business you might own.

Stop for a minute. Would you buy a car only as the result of seeing what someone else had? You would probably first think about what you need it for and who was going to be driving it. Extensive commuting might demand a car with good gas mileage, whereas using it only to shop and for vacations might make trunk size more important. If you were the only driver, a sports car might be fun; a son with only a new learner's permit, however, might make you hold off on the sports car a few years.

In purchasing a computer system, many of these same considerations are important. For most microcomputer owners, choice is based on cost, reliability, and ease of use.

The most important question is, What do I want to do with the system? What jobs are to be performed? A computer used only for games can be quite a different system than one used to generate reports for school.

Before making any purchase, the first step is to determine the system's purpose: Why do you need a computer? The system is made up of both hardware and software, so the purchase of either one depends on the other. The perfect software package is useless if it cannot be run on your computer; the perfect computer is useless if no software is available to meet your needs. Remember: Although the software you want may be available, it may not be available for the system you are considering.

Identifying the functions the computer is to perform is essential. You should do this *before* considering either software or hardware. Figure 6.8 identifies some functions. You may wish to add to the list.

A second preliminary step is to establish your budget: How much can you afford to spend? What do you already have that could be used with the microcomputer to reduce the initial cost? A TV set could be used as the video monitor. A cassette recorder could be used to store data on tape.

Once you establish the general functional requirements and budget, you can look in more detail at the software and hardware requirements.

Criteria for Evaluating Software

Once the computer is purchased, the search for software continues. How do you choose good software?

Software can be purchased either by mail or from a retail store. Usually,

- _____ Games
- _____ Word processing
 - _____ Letters and memos
 - _____ Research papers and manuscripts
 - _____ Specialized terminology and symbols
- _____ Personal record keeping
 - _____ Appointment calender
 - _____ Address book or mailing lists
 - _____ Stock market activity
 - _____ Taxes
 - _____ Itemized deductions
 - _____ Cash management and budgeting
 - _____ Other:
- _____ Accounting
- _____ Graphics
- _____ Programming
- _____ Educational packages and tutorials
- _____ Communications with services such as CompuServe

Figure 6.8

This list summarizes some of the functions of a micro. The most important consideration to ask is, "What do I want to use it for?"

purchasing from a store is more expensive. Is it then better to purchase it by mail?

The greatest advantage of purchasing from a store is that you can usually see a demonstration of the software. If it does not do what you anticipated, you can walk out without it. Mail order does not usually permit a demonstration; you base your choice on a written description or from already being familiar with what the program does.

Once you see the package, how do you evaluate it? First, does the software need to be purchased or will you be writing any of it? You may be a programmer. If the software is unavailable, you will write it. Even if the software is available, you may write the program anyway. Perhaps you have no interest in programming; in this case, everything you need must be available for purchase.

Second, if you purchase the software, does it do what you need? Does it meet all your requirements? If you are buying a program that keeps track of the checks you write, can it handle the number of checks you write annually? Will it flag those checks affecting your tax returns?

Third, how efficiently does the package handle data? If you purchase

the check-balancing program mentioned above, how many times do you have to enter the same information? Do you enter it only once? Is it used both for balancing and taxes, or do you have to enter the data once for each? The latter would be very inefficient and would more likely contain errors. Can you perhaps use the data collected for another program without rekeying it?

Fourth, what is the quality of the package? Does it do what it says it will? What if requirements change: Will the vendor modify the program, or can you trade it in against a newer version? This is particularly important for business software.

Fifth, what about the documentation? Is it clear—can you follow the instructions? Is it concise—is all the information you need stated clearly but briefly? Is it well-organized? Can you find the information you need? Is it easy to use—does it have an index? Is it accurate—does it tell you to insert card D into port C, and you find that there is no port C in the illustration? Documentation should be written for the user. Good documentation is written for you, is clear to you, and is accurate when you follow the instructions.

Finally, the best source is to talk to other users of the package you are considering buying. Again, computer clubs, fairs, and magazine articles provide invaluable information. You may again want to prepare a checklist of software requirements before you go shopping. When evaluating a software package, consider these questions:

1. Do you need a demonstration? If so, you probably want to buy from a store, not by mail. If not, mail order is cheaper.
2. Does it meet your requirements?
3. How efficiently does it handle data? Will it work with other packages you own or may purchase?
4. Is it a quality package: Will it do what is claimed? What about revisions and modifications?
5. How good is the documentation?
6. How do other users like it?

Criteria for Evaluating Hardware

A first consideration in choosing hardware is again deciding what the computer's functions will be. Reports probably require a good printer, whereas games may never produce printed output. A black-and-white monitor is fine for reviewing written material, whereas "Battle Between the Galaxies" really loses something when it is not in full color.

A second consideration is Who is going to be using it? What is the user's background? The electronic hobbyist may love to tinker with the machine and figure how it works on her own, whereas another user may just want to get the job done quickly and efficiently and forget it. One needs

good, clear documentation; the other wants only to know how to put the microcomputer back together after she has completely taken it apart.

How much money do you have to spend? Can you buy what you want? This is a real limitation on those wants. Perhaps you are willing to give up some features to save money. Perhaps the cost is less than you anticipated; you might even be able to get some of those "nice but can live without" features.

Finally, what is the vendor's reputation? Many manufacturers make microcomputers. Some probably will be around in five years, others probably will not. The quality of the microcomputer may have little to do with the success of the company producing it. How important is it to you for the vendor to be here next year, two years, or ten years from now? What are you willing to pay for that security?

Remember that your needs are unique. As a user, you are unique, and the choice of a microcomputer has to be as individual as you and those needs are. As you make that choice, take advantage of exhibits, courses, magazine articles, computer clubs, fairs, workshops, and so on.

Caring for Your System

Modern microcomputers are relatively maintenance free and perform well in environments that would have been unfriendly to older computers. For example, in the past computers had to be stored in heavily air-conditioned rooms. This is no longer necessary.

It is a good idea to keep the computer clean and free of dust by using plastic dust covers that slip over the VDT or printer when the computer is not in use.

Be sure to install the computer properly and to attach all peripheral devices according to the instructions provided. If you are concerned that surges on the electrical line providing power to the computer may occur, you can purchase adaptors to regulate the power supply.

If your system uses diskettes, you should remember several additional facts:

1. The surface of the disk scratches easily. Do not touch any of the exposed surfaces; hold it by the jacket.
2. Keep the diskette in the protective storage envelope whenever it is not in use.
3. Never insert a disk into the drive or remove a disk from the drive while the red light is on.
4. Keep diskettes away from magnetic fields such as radios, TVs, and air conditioning motors. Data stored on a diskette may be erased by exposure to a strong magnetic field.

5. Keep diskettes away from heat.
6. If you label a diskette, never write directly on the diskette jacket. Write on a label and attach the label to the jacket.

Trends in Microcomputers

Microcomputers are changing rapidly; the hand-held microcomputer is now available, and the supermicro is coming into the marketplace. What then are the trends in hardware and software development, in sales, and in usage?

Trends in Development

Trends in the development of microcomputer hardware and software include the growth of larger and more powerful microcomputers—16-bit and 32-bit word supermicros. These supermicros are also capable of something new for microcomputers: **multitasking**, the concurrent execution of more than one job. They are also multiuser, capable of supporting more than one user at a time.

The CRT screens are becoming sharper, with more **pixels** (short for “picture elements”) to the square inch. They are also becoming more interactive and friendly as touch screens and graphics pads grow in popularity.

Software is also becoming more friendly as more and more programs are icon driven. An **icon** is an image; in an icon-driven program each activity on the menu is represented by a picture of the activity.

As memory size continues to grow, more languages formerly used exclusively on mainframes are being used on microcomputers: COBOL, FORTRAN, Pascal, as well as a growing number of fourth-generation languages (see Chapter 1).

More portable operating systems also are being developed. These portable operating systems can move from one machine to another rather than being exclusive to one machine. This eases the problems encountered when a new machine is purchased and the software purchased to run under one operating system is no longer supported under the new one. If the operating system itself is portable, there is a much greater chance that software will run on it.

Trends in Usage

Microcomputers are ceasing to be only a personal computer; they are becoming more of a shared resource. One recent study found that the average office personal computer is shared by two or three persons and that one-

fourth of all business personal computers are used by ten or more persons. This is not concurrent use but refers to many individuals using the same computer at various times.

Microcomputers are increasingly being used to form **local area networks (LAN)**, where they are not only able to handle their own processing but also to talk to other microcomputers as well as to the mainframe.

The amount and variety of software continues to grow. With the availability of more and easier-to-use software, more non-data processing professionals are using microcomputers. Information centers that provide help for these users are springing up in many companies.

Today many articles discuss the ethics of making illegal copies of software. Much is written about how to regulate the reproduction of software better and eliminate illegal copies. Data processing personnel want the ability to make a backup copy in case the original is destroyed. The authors of software want to receive their just profits from the sales. How can backup copies be permitted while prohibiting copies that may be used by someone unauthorized to do so? The conflict has yet to be solved to everyone's satisfaction.

Trends in Sales

Microcomputer sales continue to increase, but this has brought many companies into the competition. In 1984, approximately 350 companies were producing microcomputers. This crowding of the market suggests that producers will thin out.

Summary

Microcomputer sales are booming. As they are becoming more powerful, it is becoming more difficult to distinguish between a powerful microcomputer and a small minicomputer. Basically, a microcomputer is a computer built around a single microprocessor chip.

Hobbyists, big and small businesses, educators, and many others use micros. Although we once thought of them as stand-alone, personal computers, we are now beginning to see more of them used as a shared resource, with several co-workers using one microcomputer. Rather than being used as stand-alone devices, many microcomputers are now used with a mainframe or other microcomputers as part of a network.

AT XFIELDS: CONCLUSION

Pat thought of all the suggestions she had heard about how to select a microcomputer. She thought it was strange to consider the software first, but after David had explained why to her, it made sense. Next Wednesday there was a meeting of the local computer club at the town library. Dave had invited her to go with him. She thought it would be a good place to start. He had said that sometimes one could get a good deal on buying equipment from a member who wanted to upgrade his or her system.

Everyone she had talked to stressed that to select the best equipment for her family, she first had to know what she wanted to do with it. She thought she'd talk it over with the kids tonight and think about what she wanted to do herself. After talking to so many people, she could think of many new uses and benefits. Maybe she'd start making those lists of uses tonight.

Exercises

1. What is a microcomputer?
2. What is a super microcomputer?
3. How are microcomputers being used today?
4. How are microcomputers being used as parts of networks?
5. What is a multiuser microcomputer?
6. List the things you would consider before purchasing a microcomputer.
7. What would you consider before purchasing software?
8. Describe any special care a microcomputer and its peripheral equipment require.

Projects

1. Visit a local microcomputer vendor. Find out all you can about one brand of the hardware they sell. If possible, talk to some owners of that type of equipment. Report on what you find out.

2. Visit a local computer club. Talk to some of the members to find out what goes on at the meetings. Report on what you find.
3. Select one microcomputer manufacturer who is on the New York or American Stock Exchange. Graph the sales history of its stock for the past year or two. If you find any large changes in the selling price of the stock, try to find out what happened at that time to cause it.